THE WING VENATION OF THE JASSIDAE.

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The present paper was undertaken several years ago at the suggestion of Professor Herbert Osborn. At that time it was thought that the wing veins of Homopterous insects could be identified in the adult stage by carefully comparing them with the venation of the Cicadidæ as determined by Comstock and Needham '98–'99. This, however, was found to be impracticable as it was soon discovered that the wing veins of most of the Homoptera have been greatly reduced and much modified from the Cicadid type. The study was then discontinued until the spring of 1910, when it was resumed by studying it from the standpoint of the nymphal wing pads.

At first the wing pads were removed as carefully as possible and mounted in glycerine jelly, as recommended by Comstock and Needham '98–'99. Later on many wing pads were mounted in xylene damar as recommended by Miss Patch '09. It was soon discovered, however, that just as good results could be obtained by mounting the wing pads in water. These wing pads were then either photographed or drawn with the aid of the camera lucida. For most Jassidæ it was found more satisfactory to draw them with the camera lucida. This is due to the fact that the outer covering of the wing pad is very thick and frequently dark colored. In addition many of the wing pads were so thick that, using the high powers necessary, it was found to be impossible to bring all parts of all the tracheæ into sharp focus at the same time. This lead to some confusion as many of the wing pads are provided with long spines which make the interpretation of the tracheæ difficult, as many of the spines are so placed as to appear in photographs as branches of the tracheæ which are slightly out of focus.

After the drawings were finished they were carefully compared many times over with wing pads from nymphs collected at later dates. If any marked differences were noted drawings were made and these again compared with the pads from nymphs collected at later dates. In this way, it is believed that all errors that might arise have been corrected or eliminated. The nymphal wing pads shown in the plates have been carefully selected from these drawings or redrawn from photographs.

The adult wings shown have been drawn with the aid of the Edinger drawing apparatus and have been selected, for the most part, from adults showing the normal venation. In a few cases, however, wings have been used which show the presence of unusual cross veins or the absence of usual cross veins.

In spite of the fact that many different methods of mounting were tried, several genera did not yield satisfactory mounts. The most conspicuous genera, in this respect, were *Kolla* and *Tettigoniella*. In spite of the fact that several hundred wing pads of these two genera were mounted from specimens collected from early spring to late summer, no satisfactory mounts were secured. Certain species in other genera show this same characteristic. Perhaps the most conspicuous species, in this respect, is *Diedrocephala versuta* Say. Nymphs of this species can be found in great numbers at Raleigh, North Carolina, throughout the season. Yet in spite of the fact that they were collected in large numbers and treated in many different ways no satisfactory wing pads of *Diedrocephala versuta* have been secured.

It is also necessary to secure the nymphs at the proper time. Some little time before the insect molts, the wing is very much crumpled in its sheath. This is especially true of the last molt. This is unfortunate as, in many cases, the older wing pads are necessary for determining the homologies of some of the tracheæ and veins. As already pointed out by Comstock and Needham '98–'99 the best results can be secured by selecting the paler colored individuals.

In all twenty-five genera of *Jassidæ* have been studied in the preparation of this paper. These genera represent such forms as could be readily secured in the vicinity of Raleigh, North Carolina. They contain representatives of all of the subfamilies and tribes of *Jassidæ* commonly found in Eastern North America.

In the course of this study many hundreds of nymphs have been collected and their wing pads studied. It has not always been found possible to remove the wing pads so as to secure the body tracheæ. The writer does not consider this important, however, as all of the pads have been removed close enough to the base to assure him of the homologies of the principal tracheæ.

This paper is founded upon the work of Comstock and Needham '98–'99. It adopts the same system they propose for naming the veins and for naming and numbering the cells, as the writer believes that this system is the only logical one that has been offered. An attempt made to homologize the veins of adult *Homoptera* and a subsequent study of the tracheation that precedes venation, has thoroughly convinced the writer that the Comstock-Needham system is the only logical one.

THE FORE WING.

The type of the fore wing of *Jassidæ* is fairly uniform but in order to point out the difference that exists the tracheæ will be considered in detail beginning at the costal margin.

The wings of *Jassidæ* show marked specialization by reduction. This reduction is usually accompanied by the atrophy of one of the branches of one of the main tracheæ and the shifting of a branch of a neighboring trachea until it occupies the region of the atrophied trachea. This is well illustrated in the atrophy of M_{1+2} of the fore wing which is discussed below. Another excellent example of the same thing is found in the *Typhlocybidæ* where M_{3+4} occupies the region usually traversed by Cu_1. The atrophy of these tracheæ with the subsequent shifting of other tracheæ which take their places gives to the wings of the *Jassidæ* their characteristic aspect.

THE COSTA OF FORE WING.

The costal trachea is absent in all of the Jassid wings that have been examined with the exception of *Gypona* (Fig. 8). Here the costal trachea is long being almost as long as subcosta and running parallel with it throughout its length. In no other Jassid was any trace of Costa found. In all cases the nymphal pad was removed as near the base as possible and the body trachea was examined for traces of the costal spur but no trace of such spur was found. This was due to the fact, perhaps, that it is impossible to get any great length of the body trachea in such a dissection. In a few cases, however, a considerable length of the body trachea was secured (Figs. 3, 5, 62, 64). This indicates that Costa has practically disappeared from the *Jassidæ*.

THE SUBCOSTA OF THE FORE WING.

The subcostal trachea in the *Jassidæ* is very anomalous. It reaches its greatest length, in the genera examined, in the genus *Jassus* (Fig. 60), where it passes beyond the apex of the wing and replaces R_2 and R_3 in the ambient vein. Subcosta is slightly shorter in *Gypona* (Fig. 8), of about the same length in *Spangbergiella* (Fig. 20), also in *Agallia* (Fig. 1). In *Acinopterus* (Fig. 41) it is still shorter barely reaching R_2. In *Platymetopius* (Fig. 26) it is about half the length of the main stem of Radius. No further evidence of the presence of Subcosta was found although the Subcostal vein on the border of the wing is well developed in all of the adult wings which the writer has examined and it shows very clearly as a distinctly lighter area in all the older nymphs examined. This series undoubtedly shows how the subcosta has atrophied in Jassidæ.

THE RADIUS OF THE FORE WING

The radial trachea in the fore wing of *Jassidæ* is typically two-branched although in some forms three and even four branches do occur. The two branches of the typical radius represent R_{2+3} and R_{4+5}. R_1 has almost completely disappeared from the fore wings of the *Jassidæ*. It does occur, as a delicate branch, in a few genera but gives rise to a very characteristic cross vein between subcosta and radius which is known currently as the "nodal vein". The nodal vein, however, is a very anomalous one and its characters will be discussed later. R_1 has been found in the following widely separated genera, *Oncometopia* (Fig. 3), *Scaphoideus* (Fig. 44) and *Typhlocyba* (Fig. 64). In other genera there remains a distinct cross vein connecting subcosta with the main stem of radius, or subcosta with R_{2+3}. This vein, which is usually referred to as the nodal vein, undoubtedly represents the remnant of R_1 or R_2. Or it may be considered as a vein which merely followed a weak lateral branch of R or R_{2+3}, which either happened to be connected with the main stem of radius, when it resembles R_1, or it may have happened to be connected with R_{2+3} in that case it resembles R_2. The writer is inclined to think that this is a distinct vein representing in some cases R_1 and in others R_2.

Trachea R_1 is very conspicuous in *Oncometopia* (Fig. 3), *Scaphoideus* (Fig. 44) and *Typhlocyba* (Fig. 64). The resulting cross vein is attached to radius in some species of *Scaphoideus* (Fig. 53) and in *Typhlocyba* (Fig. 77), but in *Oncometopia* the resulting cross vein is sometimes absent in the adult wing, and is sometimes present as a fairly strong cross vein uniting with radius near the point where it branches into R_{2+3} and R_{4+5}. In other cases, it appears as a fairly strong cross vein distinctly uniting subcosta with R_{2+3}. The whole question seems to be settled by reference to figure 3 which was taken from a half grown nymph. This wing pad shows a weak R_1 which runs parallel to R_{2+3} for a considerable distance and then bends toward the costal margin. All attempts to secure older nymphs whose wing pads would show the forming veins along the tracheæ failed owing to the thickness of the pads and the large amount of coloring matter. Inasmuch as trachea R_1 does run parallel with R_{2+3} for some distance it would seem to indicate that the point of attachment of the cross vein which follows the trachea might be at any one of various points along the radial vein over a considerable length of that vein.

In other cases this cross vein is very evidently R_2. It appears as a weak lateral branch of R_{2+3} in *Parabolocratus* (Fig. 23), as a somewhat stronger branch in *Goniagnathus* (Fig. 25), as a still stronger branch in *Phlepsius* (Fig. 48). In *Acinopterus* (Fig. 41) the trachea gradually diverges but the forming vein is set at nearly a right angle to R_{2+3}. In *Jassus* (Fig. 60) trachea R_2 reaches its greatest size for any of the genera examined and the vein in the adult wing seems to follow the course of the trachea rather closely. In *Chlorotettix* (Fig. 43) tracheæ R_2 and R_3 are united for nearly their entire length, being separated only at their tips. This character seems to be comparatively constant for the genus (Fig. 52). In still other genera the nodal cross vein is formed without being preceded by any trachea. This is especially conspicuous in certain species of *Draeculacephala* (Fig. 6) which have only one cross vein connecting subcosta with R_{2+3}. In *Eutettix* (Fig. 46) two cross veins are formed, one occupying the position of R_1 and the other the position of R_2. Neither one of these cross veins is preceded by a trachea. There is an interesting question involved in the genus *Scaphoideus*. As pointed out by Osborn '00 the nodal vein arises from radius in *auronitens* and certain other species while in *jucundus* and allied species it arises from R_{2+3}. Unfortunately the writer was able to secure nymphs of only the first group but he believes that the nodal cross vein in the *jucundus* group is the untracheated cross vein between R_1 and R_3 (Fig. 44). In this case the nodal cross vein in *Scaphoideus* would be R_1 when the "nodal vein arises from discal cell" and R_2 when the "nodal vein arises from anteapical cell".

In most of the genera of the *Jassidæ* radius branches once and only once, the resulting branches being R_{2+3} and R_{4+5} (Figs. 1, 5, 6, 20, 22, 26, 28, 62), In several cases referred to above R_2 separates from R_3. In only one genus examined, *Eutettix* (Fig. 46) has R_4 and R_5 been found separated. In this case R_4 occurs as a cross vein between R_{2+3} and R_5. R_{2+3} is much atrophied and R_4 extends to the margin traversing the region usually occupied by R_{2+3}. In a single genus examined, *Empoasca* (Fig. 66), radius extends as a single unbranched trachea from the base of the wing pad to the apex. Although in the adult wing, in many cases, there is a cross vein connecting radius with the margin of the wing.

MEDIUS OF THE FORE WING.

Medius in the *Jassidæ* is typically two-branched. These branches embrace M_1 and M_2, and M_3 and M_4 respectively. M_{1+2} is well developed in *Chlorotettix* (Fig. 43) where it runs parallel to R_{4+5}. It is not so well developed in *Parabolocratus* (Fig. 23) *Platymetopius* (Fig. 26) and *Gypona* (Fig. 8). In *Deltocephalus* (Fig. 28) M_{1+2} is reduced to a mere spur. In the other genera studied medius consists of a single unbranched trachea which extends from the base to the apex of the wing pad, although in most cases there is a strong transverse vein connecting medius with R_{4+5}. The writer believes that the above series, as outlined, represents fairly well the development of medius from a two-branched condition to a single unbranched trachea. If this conception be correct M_{1+2} must have come to lie parallel with R_{4+5} and has been gradually reduced until the present time it is at most merely a cross vein connecting medius with R_{4+5}. The vein having persisted in some cases notwithstanding the fact that the trachea has been lost. This is especially evident in *Agallia* (Fig. 1), *Scaphoideus* (Fig. 44) and *Eutettix* (Fig. 46).

In the *Typhlocybidæ* (Fig. 64 and 66) medius is very evidently two branched. In *Typhlocyba* (Fig. 64) R_{4+5} is greatly reduced and resembles a cross vein. The usual position of R_{4+5} is occupied by M_{1+2}. In *Empoasca* (Fig. 66) Rs coalesces with M_{1+2} for a short distance and then diverges toward the costal border M_{3+4} being very distinct.

CUBITUS AND FIRST ANAL OF THE FORE WING.

In all of the genera of *Jassidæ* examined the cubital and first anal tracheæ were the most constant and formed one of the best landmarks in the study of the relations of the tracheæ. They are coalesced for some little distance from the base of the wing.

Cubitus is frequently two branched (Figs. 8, 22, 23, 25, 43, 48, 60). Here again we can trace almost a complete series from a form like *Jassus* (Fig. 60) or *Goniognathus* (Fig. 25), where Cu_2 is equally as important as Cu_1, through intermediate forms like *Gypona* (Fig. 8), to forms like *Phlepsius* (Fig. 48) where Cu_2 is reduced to a mere spur.

In the *Typhlocybidæ* (Fig. 64 and 66) M_{3+4} has come to occupy the region usually occupied by Cu_1 and cubitus is unbranched and diverges strongly toward the anal border which gives it the appearance of having lost branch Cu_1 and having retained Cu_2.

The first anal vein lies along the anal border of the claval suture. It has not been usually recognized as a distinct vein owing to the fact that as a vein it is rather inconspicuous while the claval suture or fold is very distinct. It is, however, preceded by a conspicuous trachea in all of the genera studied.

SECOND AND THIRD ANALS OF THE FORE WING.

The second and third anal tracheæ in the fore wing are well developed and the third anal is frequently two branched (Figs. 3, 5, 6, 20, 23, 25, 41, 46, 60).

THE HIND WING.

In all of the *Jassidæ* proper the hind wing is very uniform. No costal or subcostal tracheæ have been discovered although the subcostal vein was well defined in all of the older nymphs studied (Figs. 9, 24, 45, 47).

RADIUS OF THE HIND WING.

The radius is typically two branched in the hind wing of the *Jassidæ.* Several mounts of *Spangbergiella* (Fig. 21) failed to reveal anything but a single unbranched radial trachea. In the adult hind wing (Fig. 35) there is faint indication of a vein in the position usually occupied by R_{2+3}.

R_{2+3} reaches its greatest development in *Draeculacephala* (Fig. 7) where it forms the tracheæ that precedes the whole of the ambient vein. In many forms, however, it is very much atrophied (Figs. 24, 45, 47, 65) while in *Empoasca* (Fig. 67) the radius is a simple unbranched trachea. The radius of the *Typhlocybidæ* coalesces for a considerable distance with M_{1+2} (Figs. 65 and 67).

MEDIUS OF THE HIND WING.

Medius of the hind wing is two branched in all of the genera that have been examined. In the *Typhlocybidæ*, however, M_{1+2} coalesces with radius for some distance and M_{3+4} coalesces with cubitus for almost its entire length so as to appear as a cross vein in the adult wing connecting medius with cubitus (Fig. 80). In the other genera studied M_{1+2} is connected with R_{4+5} by a short cross vein and M_{3+4} is connected with cubitus by a similar short cross vein. In some cases the latter cross vein is greatly reduced and in Jassus (Fig. 69) R_{4+5} and M_{1+2} coalesce for a short distance and again separate before reaching the margin of the wing.

In all of the genera studied cubitus is a single unbranched trachea in the hind wing. Its relations with medius in the *Typhlocybidæ* have already been discussed. As in the fore wing, cubitus and first anal are very closely united. Second and third anal are also present in nearly all cases and third anal is frequently two branched. The second anal and the anterior branch of the third anal generally coalesce for a considerable distance near the middle of their course and are usually separated again near the base of the wing (Figs. 16, 38, 57). There is always a conspicuous fold just posterior to the anterior branch of the third anal.

HISTORICAL DISCUSSION.

A comparison of the nomenclature here suggested with the nomenclature current in America and with the nomenclature as suggested by Edwards '94–96 is given in the subjoined table.

NOMENCLATURE OF VEINS

TERMINOLOGY SUGGESTED	AFTER EDWARDS	CURRENT TERMINOLOGY
Subcosta		Costal border
R+M	Cubital	First sector
Radius	Upper branch of cubital	Outer branch of first sector
R_1		Nodal
R_2	Angular	Nodal
R_{2+3}		Anterior branch of outer sector
R_3		
R_{4+5}		Posterior branch of outer sector
R_4		
R_5		
Medius	Lower branch of cubital	Inner branch of first sector
M_{1+2}		
M_{3+4}		
Cubitus	Brachial	Second sector
Cu_1		
Cu_2		
Anal furrow	claval suture	claval suture
First Anal		
Second anal	anal	outer claval
Third anal	axillary	inner claval
Ambient		

NOMENCLATURE OF THE CELLS

TERMINOLOGY SUGGESTED	AFTER EDWARDS	CURRENT TERMINOLOGY
Subcosta	costal	
Radius	subcosta	
R_1		
R_2	Apical	apical
First R_3	subapical	anteapical
Second R_3	apical	apical
First R_5	apical	anteapical
Second R_5	apical	apical
First Medius	basal	
Second Medius	superbrachial	
First M_4	Subapical	anteapical
Second M_4	apical	apical
Cubitus	brachial	
Cu_1	apical	apical

SUMMARY.

The present paper homologizes the wing veins of *Jassidæ* with the wing veins of other orders. The wing veins of *Jassidæ* differ in the following important respects from those of other insects.

1. The costal trachea is practically eliminated from the wings of *Jassidæ*.

2. The subcostal trachea is well developed in some genera and absent in others, which indicates that it is disappearing from *Jassidæ*.

3. The radial trachea is typically two branched in *Jassidæ*, the branches present being R_{2+3} and R_{4+5}.

4. The medial treachea is typically two branched, these branches being M_{1+2} and M_{3+4}.

5. The cubital trachea is two branched in some cases and unbranched in others.

6. All three anal trachea are present, the first anal being very closely connected with cubitus. Third anal is frequently two branched.

7. The ambient vein is a composite vein in *Jassidæ*, being formed along the overlapping tips of the principal trachea.

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EXPLANATION OF PLATES.

Plate VIII.

Fig. 1. Fore wing pad of *Agallia 4-punctata* Prov.
" 2. Hind " " *Agallia 4-punctata* Prov.
" 3. Fore " " *Oncometopia undata* Fabr.
" 4. Hind " " *Oncometopia undata* Fabr.
" 5. Fore " " *Diedrocephala coccinea* Forst.
" 6. Fore " " *Draeculacephala mollipes* Say.
" 7. Hind " " *Draeculacephala mollipes* Say.
" 8. Fore " " *Gypona 8-lineata* Say.
" 9. Hind " " *Gypona 8-lineata* Say.

Plate IX.

Fig. 10. Fore wing of *Agallia constricta* Van Duzee.
" 11. Hind " *Agalia constricta* Van Duzee.
" 12. Fore " *Oncometopia undata* Fabr.
" 13. Hind " *Oncometopia undata* Fabr.
" 14. Fore " *Diedrocephala coccinea* Forst.
" 15. Fore " *Draeculacephala mollipes* Say.
" 16. Hind " *Draeculacephala mollipes* Say.
" 17. Fore " *Penthimia americana* Fitch.
" 18. Fore " *Gypona 8-lineata* Say.
" 19. Hind " *Gypona 8-lineata* Say.

Plate X.

Fig. 20. Fore wing pad of *Spangbergiella vulnerata* Uhler.
" 21. Hind " " *Spangbergiella vulnerata* Uhler.
" 22. Fore " " *Athysanus* sp.
" 23. Fore " " *Parabolocratus viridis* Uhler.
" 24. Hind " " *Parabolocratus viridis* Uhler
" 25. Fore " " *Goniagnathus palmeri* Van Duzee.
" 26. Fore " " *Platymetopius* sp.
" 27. Hind " " *Platymetopius* sp.
" 28. Fore " " *Deltocephalus* sp.
" 29. Hind " " *Deltocephalus* sp.

Plate XI.

Fig. 30. Fore wing *Xerophloea viridis* Fabr.
" 31. Fore " *Spangbergiella vulnerata* Uhler.
" 32. Hind " *Athysanus exitiosus* Uhler.
" 33. Fore " *Athysanus exitiosus* Uhler.
" 34. Fore " *Parabolocratus viridis* Uhler
" 35. Hind " *Spangbergiella vulnerata* Uhler.
" 36. Fore " *Goniagnathus palmeri* Van Duzee.
" 37. Fore " *Platymetopius* sp.
" 38. Hind " *Platymetopius* sp.
" 39. Fore " *Deltocephalus obtectus* O. & B.
" 40. Hind " *Deltocephalus obtectus* O. & B.

Plate XII.

Fig. 41. Fore wing pad of *Acinopterus acuminatus* Van Duzee.
" 42. Hind " " *Acinopterus acuminatus* Van Duzee.
" 43. Fore " " *Chlorotettix viridia* Van Duzee.
" 44. Fore " " *Scaphoideus* sp.
" 45. Hind " " *Scaphoideus* sp.
" 46. Fore " " *Eutettix* sp.
" 47. Hind " " *Eutettix* sp.
" 48. Fore " " *Phlepsius* sp.
" 49. Hind " " *Phlepsius* sp.

PLATE XIII.

Fig. 50. Fore wing of *Acinopterus acuminatus* Van Duzee.
" 51. Hind " *Acinopterus acuminatus* Van Duzee.
" 52. Fore " *Chlorotettix viridia* Van Duzee.
" 53. Fore " *Scaphhoideus productus* Osb.
" 54. Hind " *Scaphhoideus productus* Osb.
" 55. Fore " *Thamnotettix kennicottii* Uhler.
" 56. Fore " *Eutettix subaenea* Van Duzee.
" 57. Hind " *Eutettix subaenea* Van Duzee.
" 58. Fore " *Phlepsius* sp.
" 59. Hind " *Phlepsius* sp.

PLATE XIV.

Fig. 60. Fore wing pad of *Jassus olitorius* Say.
" 61. Hind " " *Jassus olitorius* Say.
" 62. Fore " " *Cicadula* sp.
" 63. Hind " " *Cicadula* sp.
" 64. Fore " " *Typhlocyba* sp.
" 65. Hind " " *Typhlocyba* sp.
" 66. Fore " " *Empoasca mali* Le B.
" 67. Hind " " *Empoasca mali* Le B.

PLATE XV.

Fig. 68. Fore wing of *Jassus olitorius* Say.
" 69. Hind " *Jassus olitorius* Say.
" 70. Fore " *Cicadula slossoni* Van Duzee.
" 71. Hind " *Cicadula slossoni* Van Duzee.
" 72. Fore " *Dicraneura mollicula* Bohem., redrawn from Melichar.
" 73. Hind " *Dicraneura mollicula* Bohem., redrawn from Melichar.
" 74. Fore " *Eupteryx vanduzei* Gill., redrawn from Gillette.
" 75. Hind " *Eupteryx vanduzei* Gill., redrawn from Gillette.
" 76. Fore " *Dicraneura cruentata* Gill., redrawn from Gillette.
" 77. Fore " *Typhlocyba illinoiensis* Gill.
" 78. Hind " *Typhlocyba illinoiensis* Gill.
" 79. Fore " *Empoasca mali* Le B.
" 80. Hind " *Empoasca mali* Le B.